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(54) METHOD AND APPARATUS FOR PHOTOEPILATION

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ABSTRACT

Photoepilation apparatus comprises a needle or probe carrying a single protected optical fiber which is supported throughout its length adapted to be connected into a photoepilation system including a gaseous discharge source of light energy. The free end of the probe is tapered with a gradual taper to a relatively fine diameter to enable said free end to be brought close to the follicle entrance of a hair shaft or body it is desired to remove. The method disclosed includes applying light energy in flashes through the use of the optical fiber at the entrance to a hair follicle.

The invention herein is concerned with the field of cosmetics known as depilation and is specifically directed to an improved method for hair removal and improved apparatus for achieving the same.

There are several methods which are generally used for removal of hair or depilation including the use of short wave electrical energy, thermolysis, galvanic action and combinations thereof. All of these methods involve pain and discomfort for the patron. Various types of apparatus are used which are cumbersome and expensive. Efforts to utilize laser energy have been abandoned because of the pain and discomfort involved but also because of the danger to the patron.

In recent years one prior art method and apparatus utilized a method which is called photoepilation because the principle consisted of removing hair by means of photoenergy. The vascular papilla of the hair body was subjected to flashes of light from a xenon gaseous discharge lamp by leading the light through a fiber-optical conduit into the hair follicle, down the follicle and to the vascular bed of the hair body. This would destroy the hemoglobin in the vascular bed by coagulation. When the vessels of the papilla were thus coagulated the hair body was in effect rendered lifeless and its bond with the papilla was so weakened that the hair body could be pulled out of its follicle without pain or discomfort.

The concept of this method was good but the manner in which it was utilized suffered from disadvantages which eventually led to a discarding of the method. The apparatus was deemed useless for any other purpose and was thus abandoned by those who owned the same. These disadvantages are explained hereinafter.

In the photoepilation method using xenon light energy as practiced heretofore, the polished end of a fine optical fiber carrying the light energy had to be inserted into the follicle of a hair body. This was painful and annoying. The degree of pain and annoyance depended to some extent upon the location of the follicle and the thickness of the hair body as well as the firmness with which it was rooted. It was believed at the time of use of this method that it was desirable to get the free end of the fiber as close as possible to the papilla and hence the operator tried to push the fiber down into the patron's follicle as far as it could be comfortably tolerated.

The procedure followed was to insert the fiber and apply a few flashes of light, remove the fiber, apply tension to the hair to see if it would release and to reinsert the fiber and repeat if the hair could not easily be withdrawn. This was not only painful but often resulted in scratching or even piercing of the interior wall of the hair follicle because the operator could not

see where the leading free end of the fiber was going. The axial end face would normally be quite sharp around the edges because the axial end of the fiber itself is best highly polished to transmit the maximum of light and because the cylindrical surface of the fiber was protected by a sheath of stainless steel metal. Patrons' tolerances to the discomfort often dictated the depth of penetration.

The fact that the fiber had to be inserted into the skin of the patron meant that the fiber end and housing in which it was mounted had to be sterilized which was not readily capable of being effected. As a result, infections could and did result. Further, regulatory bodies concerned with public health were concerned and problems of licensing and control become involved.

The apparatus of the type that was used with the prior art of photoepilation described included a probe which was a small cylindrical steel member secured to a flexible cable that led the light energy from the source to the cable end. The probe had a single glass fiber encased in a protective steel sheath disposed in the center of the probe coaxial with the exterior of the cylindrical member. One end of the fiber was arranged flush with the end of the probe that was secured to the cable and the probe end was threaded into a connector or fitting that coupled the light energy from a light-

transmissive member within the cable to the fiber through an oil-filled chamber.

The second or free end of the fiber was arranged to protrude from the free end of the probe opposite the connected end for a distance of about a quarter of an inch. The free end of the fiber as understood from the description was adapted to be inserted into the hair follicle of the patron. This free end was unsupported by the probe and for strength had the steel sheath surrounding its cylindrical surface with its axial end face exposed. Both the axial end face on the free end and on the end which is connected to the cable would be highly polished to transmit the maximum of light.

The dimensions of the free end of the optical fiber are of consequence in considering the impact of the invention herein because these dimensions in the prior art were dictated by the method that was deemed necessary to be used. Since the fiber had to enter the follicle, it had to be long for at least the average depth follicle - namely about one quarter inch in length. Since the fiber had to enter follicles of very fine hair bodies, its diameter including that of the steel protective sheath had to be very small. Women desiring depilation of hair usually want it removed from their faces and particularly from the upper lip where the hair is very fine. The maximum diameter of the protruding fiber and

protective sheath on the prior apparatus was limited to about .007 inch. Anything larger would result in great pain or even the improbability that it could be inserted.

As can be understood, the amount of light energy which can be transmitted by an optical fiber that is about .004 inch in diameter (allowing about .003 inch for the thickness of the sheath material on opposite sides of the actual optical fiber) is not very great. Even assuming that the method of the prior art described can be used, the time required for coagulating the papillary tissues is certainly substantially less than it would be if the optical fiber could be doubled or even tripled in size. This would be impossible, of course, because no such fiber sheathed in steel could be inserted into a normal hair follicle.

Another disadvantage of the prior art method and apparatus was the fact that since the protruding end of the sheathed fiber had to be so long and so thin it was subjected to breakage. These so-called "needles" were very expensive and the breaking off of a protruding end rendered them useless in accordance with the prior method.

The invention is based upon a discovery that gives rise to an important series of advantages. The discovery is that if the axial end of the optical fiber is placed immediately adjacent the entrance to a hair follicle without inserting the same within the follicle, there is a

substantial amount of the photoenergy that will enter the follicle and pass down to the papilla and coagulate the same. The amount of energy thus transmitted is so great that the apparatus of the prior art can be used in practicing this method. The same "needle" with its protruding sheathed fiber is placed on the skin of the patron with the axial end face located at the entrance to the hair follicle and the xenon lamp is flashed several times. The hair is pulled and if it does not immediately give way, the follicle entrance is flashed several more times. There is no pain or discomfort connected with this method because the follicle is not entered. If the first group of flashes is insufficient the patron does not have to suffer the removal and reentry of the fiber end as in the prior method.

The advantage which is inherent in using even the prior apparatus to perform the method is only one benefit which flows therefrom. The other benefits are concerned with the apparatus of the invention. Since the fiber does not have to enter the follicle it can be made much thicker than the prior art fiber. Fiber and sheath combinations as thick as .015 inch can now be used. These do not have to protrude from their probe housing as far as the prior art devices and hence are robust and long-lasting. They are not subject to lateral stress because they are never inserted into the skin. They conduct substantially more photoenergy than the .007 inch fibers

of the prior devices and can thus coagulate tissues faster - thereby decreasing the time required to epilate a given number of hairs. The economy and convenience of this benefit are believed to be obvious.

These larger fibers are easier to manufacture because the tolerances are not as great. Glass or synthetic resins can be used as the fibers. The probes and protruding fibers do not have to be sterilized and since the skin is not entered, the apparatus is not classed as a surgical instrument by regulatory bodies. The operators are not as readily subject to the rigid controls of governmental regulatory bodies.

Other advantages are the fact that the skill for using the apparatus is less since there is no need to judge how far to insert the fiber under the skin, that the operator is better able to see where to place the axial fiber end; there is no requirement to probe the skin while seeking out the precise passageway below the entrance to the hair follicles.

There is described herein a probe for photoepilation, the probe having a fiber optic conduit for conducting high energy light energy to the exterior of a hair follicle at a location relative thereto closely spaced adjacent yet outside the entrance to the hair follicle.

Particularly, a preferred embodiment of the invention is described as comprising a housing adapted to have one end thereof connected to a source of high energy light from a gaseous discharge lamp and having an optical fiber therein for transmitting light from the adapted-to-be-connected end to a free end. The fiber has the axial face at the adapted-to-be-connected end flush with the housing at the adapted-to-be-connected end and has the axial face of the fiber exposed at the other end, the exposed end being disposed between a location

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flush with the free end and a location outwardly spaced from the free end a distance no greater than the distance required to permit the hair follicle to be touched by the free end yet remain exterior of the entrance to the hair follicle. The fiber is supported by the housing at both ends of the fiber and the housing has an outer configuration including a taper at the free end.

The exact manner in which the photoenergy is transmitted to the papilla from the entrance thereof is not precisely understood but is believed to occur on account of the natural oils in the follicle which transmit light. On this account the method of the invention was originally practiced by applying mineral oil to the skin at the follicle entrance and attempting to work it into the follicle. Later it was learned that this is not necessary.

It will be appreciated that the tissue which is devoid of pigment will not absorb the photoenergy and hence the outer surface of the skin in the vicinity of the follicle entrance will not be substantially affected, nor will the inner lining of the follicle. Instead the light energy will most strongly affect the hemoglobin in the papilla where the vessels nourishing the hair are located. This, then is where the coagulation takes place.

In the description which follows there are described preferred embodiments, but only by way of example, from an examination of which the method of the invention and

the apparatus for practicing the same will be understood. Advantages and benefits not specifically mentioned will become apparent to those skilled in the art to which the invention pertains from a study thereof.

In the drawing which accompanies this specification:

Figure 1 is a sectional view on a greatly enlarged scale through the skin of a subject having photoepilation performed on a hair papilla and showing the method practiced according to the invention, with a fragment of a probe depicted in use;

Figure 2 is an enlarged mediam sectional view of the probe of the invention;

Figure 2A is a fragmentary sectional view on a larger scale illustrating the sheathed optical fiber;

Figure 2B is a fragmentary sectional view through the outer end of a probe of modified form showing the manner of using the same to practice the method of the invention;

Figure 3 is a side elevational view, partially broken away, illustrating the probe of the prior art; and

Figure 4 is a side elevational view of another modified form of the probe of the invention.

As explained above the improvement over the prior art resides in the construction of the probe and in the manner of using the probe.

Initially it should be clear that the method of the invention can be practiced using the probe of the

prior art but will give better results if used with the probe of the invention. The reason simply is that the prior art fibers are required to be so much thinner than the fibers of the invention can be and hence cannot transmit as much photoenergy per flash of the xenon lamp.

In Figure 1 there is illustrated on a greatly exaggerated scale a sectional view through the skin of a subject that is having the photoepilation process of the invention performed in order to remove hair bodies. In this instance a section is taken through a hair body or shaft 10 and its hair follicle 12, there being a probe 14 applied in the manner taught by the invention to effect epilation.

The derma of the subject is designated 16 and the epidermis 18 covers the same with an entrance 20 to the follicle 12 opening at 20 to the outer surface of the epidermis 18. The inner wall of the follicle 12 has a layer equivalent to the epidermis 18 that comprises a lining 22. The shaft 10 terminates at its inner end in a bulbous portion which may be termed the root 24, the follicle 12 and lining 22 conforming in configuration to the root 24. At the bottom of the follicle 12 there is an upwardly protruding papilla 26 which enters a portion of the root and contains a vascular network fed by an arterial vessel 28.

The hair shaft 10 and root 24 are shown rather loosely disposed within the follicle 12, but this illustration is only to explain the invention. In actuality the spacing is small between the hair body and lining 22 but there is sufficient spacing for the efficacy of the method which will be described.

At 30 are shown so-called fat glands in the derma which communicate with the follicle 12 by way of the ducts 32, these supplying the so-called natural oils that lubricate and give tone to hair. The space between the hair body 10 and the lining 22 is normally filled with some of the lubricant which is exuded by the fat glands 30.

The prior art probe 34 of Figure 3 was constructed as a hollow cylindrical housing 36 with a central sheathed optical fiber 38 passing through the same coaxially of the housing 36, held in place at the conical tip 40 by means of an annular plastic plug 42 and having a protruding portion 44. In use, the upper screw-threaded head 46 of the probe is screwed into the socket 48 (Figure 2) of a fitting 50 that is connected to a bundle of light transmitting optical fibers or a single flexible fiber, the light transmitting means being shown at 52. The optical fiber or fibers 52 are sheathed in a steel conduit 54 which in turn is protected by a relatively elastic plastic coating 56. The steel conduit 54 is swaged into the fitting 50 as shown at 58 and the coating 56 sealed at 60 to be liquid tight. The free

end 62 of the optical fiber bundle or single fiber 52 is polished for maximum light transmissivity and enters a small annular chamber 64 formed in the upper part of the socket 48 above the end 66 of the head 46. The head 46 is screwed in place with an eleastomeric O-ring 68 spacing the same from the uppermost end of the socket 48 in order to form the chamber 64 while sealing the connection.

The sheathed optical fiber 38 of the probe 34 and that of the probe 14 are identical in construction and hence designated by the same numeral 38. They are not of the same thickness necessarily. There is a central single glass or other optically transmissive fiber 70 and an outer sheath 72 of steel, the combined article being somewhat resilient and bendable since its overall outer diameter is quite small. The prior art sheathed fiber 38 typically has been .007 inch in diameter because of its need to enter into a follicle. The sheathed fiber 38 of the invention is preferably larger because of the different method of use. In practice, success has been achieved by increasing the diameter of the fiber .002 inch resulting in a total diameter of .009 inch. Larger diameters - up to at least .015 inch will be even more effective.

The sheathed fiber 38 passes through the head 46 and is flush with the upper surface 66. This flush end is polished for maximum light transmissivity of the fiber 70.

When the probe 14 or 34 is assembled to the fitting 50, the fitting 50 is first inverted to form a cup and a

small quantity of mineral or other stable oil is poured into the chamber 64. Thus, when finally assembled, if the free end 62 of the light transmissive means 52 and the fiber 70 do not accurately meet and engage directly, the light energy will be transmitted through the oil 74 so that the fiber bundle 52 and fiber 70 are well coupled together insofar as light energy transfer is concerned. This technique is known.

In use, the protruding portion 44 of the prior art probe 34 is inserted alongside of the shaft 10 as well into the follicle 12 placing the polished axial end face thereof quite close to the papilla 26. Then, under the control of the operator, several short flashes of light energy are transmitted through the optical fiber system to coagulate the hemoglobin of the papilla. It is known that the papilla furnishes the new cells that cause the hair to grow, these cells being pushed forward from the bottom of the root so that the hair grows axially outwardly. Putting the hair shaft out by the root will not destroy the hair. This requires the destruction of the papilla. Accordingly, once the papilla is no longer capable of supporting growth because of the coagulation of the vessels within the papilla, there will no longer be any hair grown from the papilla. In effect the hair is destroyed.

Once the vessels in the papilla 26 are destroyed, the hair shaft 10 with its root 24 may be easily pulled out and will never re-grow.

The basic theory of the method as described is practical and effective, but the disadvantages of being required to insert the protruding portion 44 into the follicle have been mentioned. They include breakage with accompanying expensive discard of the probe; danger of infection; and discomfort of the subject. Although shown proportionately larger, the protruding end 44 in the prior art probe is of the order of $\frac{3}{16}$ to $\frac{1}{4}$ inch in length. The operator attempts to insert it as far as possible using a magnifying glass to find the entrance. Scratching of the lining 22 was common.

The probe 14 of the invention is especially intended for use with the method of the invention. It is possible to use the probe 34 in practicing the invention but not without some difficulty.

I have discovered that the light energy is capable of being transmitted the entire length of the follicle 12 and that sufficient energy will reach the papilla to effect destruction of the vessels therein. This is true even using the prior art device 34. Accordingly, I apply the free end of the sheathed fiber 38 to the entrance 20 depending on the natural oily material therein, this being shown at 75. Such natural oils are exuded by the fat glands 30 through the ducts 32 and will suffice to transmit the light energy. For added effectiveness I may bathe the epidermis 18 in a low viscosity mineral oil and rub the site of the opening 20 to work the oil down into the follicle 12 but I have found that this is not

necessary in most cases.

The probe is applied as shown in Figure 1, the construction of the probe preferably being such that there is a long shallow tapered body 76 which comes to a fine tip 78. The sheathed fiber 38 is mounted in the same manner as it is in the probe 34, except that it terminates in the tip 78, either with or without a plastic plug like 42 and its polished axial end face is flush with the tip end as shown at 80. The end 80 is located right at the entrance to the opening 20 without entering the follicle and even without the need for touching any part of the subject. It is preferably laid into contact with the upper surface of the skin at the entrance 20 in contact with oily material 75 in the follicle 12. It will be appreciated that it is practically impossible to hold the probe end a couple of thousandths of an inch from the entrance 20 during use - hence, touching the skin is the practical way of accomplishing this.

Where reference is made in the claims to placing the probe "at the entrance" of the follicle it will be taken to mean either that there is a touching or a closeness sufficient that the majority of photoenergy is directed into the follicle.

In the process of photoepilation, a few flashes of light may be applied and the hair shaft 10 grasped and given a gentle pull to see if it is loose. If not, a few more flashes and the hair shaft 10 is easily pulled

out of the follicle 12. With the method of the invention there is no difficulty involved in such trial because the probe is not engaged into the follicle. One just moves it aside and tries the hair shaft. In the case of the prior method, one would have to remove the protruding portion 44 from the follicle 12 to make the trial, then reinsert if not successful. Each time an insertion is needed, the step must be done carefully in order to try not to pierce the lining 22 and cause pain or discomfort to the subject. This effort is not always successful.

It is possible to use the probe 34 in practicing the method of the invention by just holding the very end of the protruding portion 44 at the entrance 20. One has to be careful in handling the probe 34 just in picking it up, using it and storing it, since breakage of the sheathed fiber was still possible. Additionally, the heavy structure with the stubby conical end 40 makes it somewhat inconvenient to locate and maintain position precisely at the entrance 20 while the process is going on. With the probe 14, however, the long narrow gradual taper of the end 78 makes for good viewing and easy manipulation.

The bundle of fibers 52 may be replaced by a single fiber. For example, a convenient arrangement, and one which would be easy to manipulate would have a single fiber about .02" in diameter suitably sheathed in steel and plastic coated.

The modified form of the invention illustrated in Figure 2B shows the probe 14" which has a small plastic

plug 42' in the end 78' of the probe body and a sheathed fiber 38' which is intended to be depicted as thicker than the fiber 38 of Figure 3. The end 80' in this case protrudes slightly from the probe end 78' by a small amount although not necessarily as much as the prior art end 44. Perhaps it can protrude about 1/8 inch or less. In this view the epidermis is shown at 18 with the hair shaft 10 protruding from the follicle entrance 20 and the axial end face 82 is shown touching the skin immediately at the entrance so that the light energy will be primarily directed into the entrance 20.

The modified form 14' of probe of the invention which is illustrated in Figure 4 differs from the probes 14 and 14" only in the respect that the tip 78' is curved as shown to enable reaching areas of the subject which are in crevices, etc. Also the probe 14' is more easily utilized by operators who prefer to hold the same at an angle rather than erect.

An important aspect of the structure of the invention is that because there is no need for a portion of the sheathed fiber 38 to extend from the housing 76 the fiber 38 may be fully supported within the housing. If protruding only a stub is sufficient as in probe 14" of Figure 2B. It need not be made as fine as the sheathed fiber of the probe 34 since it is not going to be inserted into a fine follicle. Thus it can be made heavier and will transmit substantially more light. For example, since the cross sectional area varies as the

square of the diameter, an increase of only .002 inch of the diameter of the glass of fiber 70 from .004 inch (assuming that the thickness of the steel sheath 72 is .0015 inch) to .006 inch results in the cross sectional area of the fiber more than doubling, with a corresponding increase in transmitted light energy. For the larger fibers mentioned the energy increase is even greater. Thus, photocoagulation can be accomplished in a shorter time than with the thinner fiber.

To indicate the proportions and dimensions of the probes, the diameters of the sheathed fibers 38 have already been mentioned, the diameter of the housing 36 is about one-eighth inch and the overall length from end to end of the probe is about one-half inch, this does not include the protruding portion 44 which may be as much as one-quarter inch. In the prior art probe 34 the small end diameter of the conical section is about one-sixteenth of an inch. The end 80 of probe 14 can be made as fine as practical to support the sheathed fiber 38; that is of the order of one thirty-second of an inch and less.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A probe for use in photoepilation apparatus and comprising a housing adapted to have one end thereof connected to a source of high energy light from a gaseous discharge lamp and having an optical fiber therein for transmitting light from said adapted-to-be-connected end to a free end, the fiber having the axial face at the adapted-to-be-connected end flush with the housing at said adapted-to-be-connected end, and having the axial face of the fiber exposed at the other end, the said exposed end disposed between a location flush with said free end and a location outwardly spaced from said free end a distance no greater than the distance required to permit the hair follicle to be touched by said free end yet remain exterior of the entrance to the hair follicle, said fiber being supported by said housing at both ends of the fiber and the housing having an outer configuration including a taper at the free end.

2. The probe as defined in claim 1 in which there is a protective metal sheath supporting said fiber at its exposed end.

3. A probe as defined in claim 1 in which the taper is a gradual one and reduces to a diameter at the said free end which enables accurate placement of said free end at the entrance of a follicle but is great enough at said free end to provide support for said fiber.

4. A probe as defined in any one of claims 1, 2 or 3 in which the diameter of the fiber is greater than that which can comfortably be accommodated by a normal human hair follicle.

5. A probe as defined in claim 2 in which the diameter of the fiber and its sheath is not less than .009 inch and not

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larger than a diameter difficult to concentrate the emerging light at the entrance to a normal hair follicle.

6. A probe as defined in any one of claims 1, 2 or 3 in which the taper commences at a location closer to the tapered end than to the free end of the housing.

7. A probe as defined in any one of claims 1, 2 or 3 in which the tapered end is curved relative to the axis of the housing.

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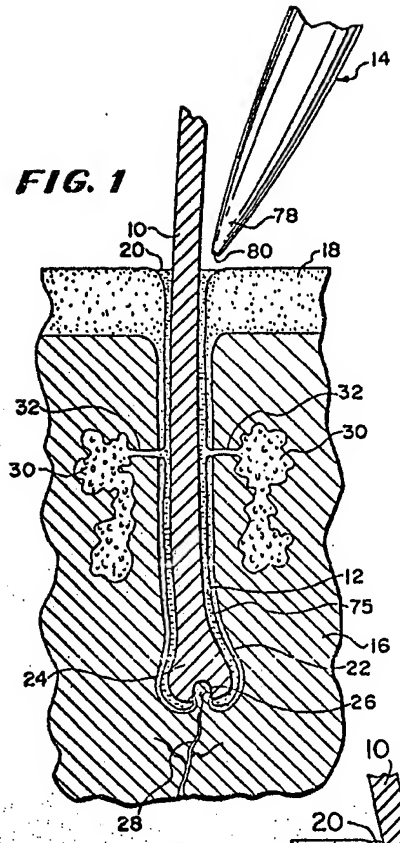

FIG. 1

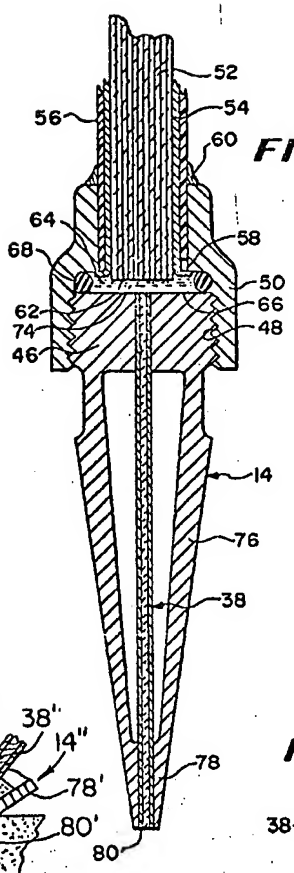

FIG. 2

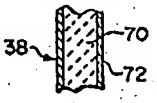

FIG. 2A

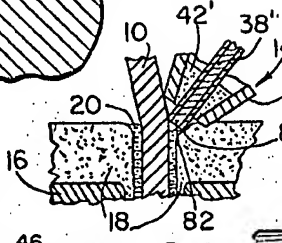

FIG. 2B

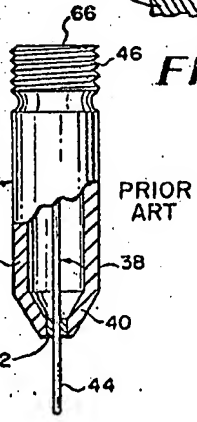

FIG. 3

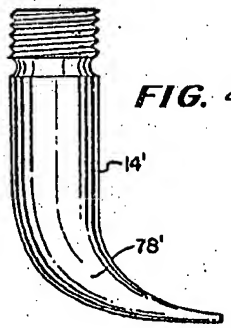

FIG. 4

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